STRUCTURE EVOLUTION IN SHEARING OF ANISOTROPIC POLYMER MATRICES FILLED WITH CLAY NANOPARTICLES

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Combination of rheological and other physical methods for detail investigation of structure transformation during flow is a stable tendency now. This approach is especially productive for heterophase systems (partially nanocomposites) because redistribution of particles at flow compared with precursor after mixing and even formation of regular morphology is typical for such kind of compositions [1,2]. In this paper an attempt to coincide Qouette flow with X-ray scattering has been done on an example of two components, active for structural research: aqueous LC solution of hydroxypropylcellulose (HPC) as a matrix, and Na-montmorillonite (MMT) particles as a filler.

For choosing the most appropriate concentrations of HPC solutions the phase diagram of HPC-water system has been constructed using micro-interference and polarizing microscopy methods. Some points of diagram were confirmed by rheological measurements. The main distinction of the phase diagram plotted in this work from existing ones is precise identification of equilibrium line separating high-temperature gel-like systems and low-temperature solutions demonstrating the usual for stiff-chain polymers transitions with increase of concentration (isotropic, biphasic, LC, crystal solvate) as binodal, but not as liquidus line. Based on these data, the 50% biphasic solution has been chosen as a matrix.

First of all, evolution of orientation for the neat solution was measured. For this aim diffractograms in 2□ and azimuthal angles were obtained. The main reflex of HPC after loading the operating unit is located in equator, but just with beginning of flow it moves to meridian (along the shear direction) and its intensity growth with shear rate (from 0 to 471 s^{-1}) up to the definite level (the order parameter is 0.66). The relaxation of oriented solution after flow with high shear rates proceeds in three stages, reflecting the healing defects created by flow instability, loss of orientation and recreation of cholesteric spiral. As higher the rate of previous flow, as faster relaxation, though the process has specific features for different stages.

Introduction to solution of 5% of MMT leads to superposition of X-ray patterns intrinsic for HPC and clay. In the region of low and moderate shear rates the clay basal reflexion is located in equator and can be detected easily. We were lucky to determine order parameters for HPC and clay separately. Starting with shear rate of ~300 s^{-1} clay orientation becomes dependent on strain time. The bright appearance of this phenomenon consists in change of location of the basal reflexion from equator to meridian at deformation times higher than 70 min (shear rate is 471 s^{-1}). This result is interpreted as transition of the columnar clay mesophase (columns are oriented along shear) to the discotic one (separate platelets are oriented along shear with the axis perpendicular to their plains directed in transversal along capillaries axis).

References:

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